COSEWIC
Assessment and Status Report

on the

Mountain Beaver
Aplodontia rufa

in Canada

SPECIAL CONCERN
2012

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

COSEWIC. 2012. COSEWIC assessment and status report on the Mountain Beaver *Aplodontia rufa* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 30 pp. (www.registrelep-sararegistry.gc.ca/default_e.cfm).

Previous report(s):

COSEWIC. 2001. COSEWIC assessment and update status report on the mountain beaver *Aplodontia rufa* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. v + 23 pp. (www.sararegistry.gc.ca/status/status_e.cfm)

Gyug, L. 1999. Update COSEWIC status report on the mountain beaver *Aplodontia rufa* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 24 pp.

Orchard, S.A. 1984. COSEWIC status report on the mountain beaver *Aplodontia rufa* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 34 pp.

Production note:
COSEWIC acknowledges Les Gyug and Doug Ransome for writing the status report on the Mountain Beaver *Aplodontia rufa* in Canada, prepared under contract with Environment Canada. This report was overseen and edited by Graham Forbes, Co-chair of the COSEWIC Terrestrial Mammals Specialist Subcommittee.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le Castor de montagne (*Aplodontia rufa*) au Canada.

Cover illustration/photo:
Mountain Beaver —

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Catalogue No. CW69-14/321-2012E-PDF
ISBN 978-1-100-20722-3

Recycled paper

COSEWIC
Assessment Summary

Assessment Summary – May 2012

Common name
Mountain Beaver

Scientific name
Aplodontia rufa

Status
Special Concern

Reason for designation
The range of this species in Canada has contracted by 29% in the last 50 years and expansion into new habitat is constrained by large rivers. Within its range, habitat loss from urban development continues, and soil compaction caused by heavy machinery limits the use of otherwise suitable habitat. Climate change may further affect this species because it requires humid microclimates and low ambient temperatures. Rescue effect potential is limited by the short dispersal rates of the species and areas of unsuitable habitat along the border with the United States.

Occurrence
British Columbia

Status history
Designated Not at Risk in April 1984. Status re-examined and designated Special Concern in April 1999. Status re-examined and confirmed in November 2001 and May 2012.

COSEWIC
Executive Summary

Mountain Beaver
Aplodontia rufa

Wildlife Species Description and Significance

The Mountain Beaver, *Aplodontia rufa*, is a muskrat-sized fossorial rodent endemic to western North America. It is the only living species of the family Aplodontiidae and is considered a 'living fossil' because of its primitive physiology and skull features. Recent genetic analysis suggests one subspecies occurs in Canada, rather than two as previously believed.

Distribution

Mountain Beavers occur within, and west of, the Cascade and Sierra Nevada mountain ranges of western North America. In Canada, they are found in southwest British Columbia (B.C.) within the Cascade Mountains and south of the Fraser River. There are five populations. The main population comprises most of the Canadian distribution, and is relatively contiguous. Two small isolated populations to the west occur on Chilliwack and Sumas mountains in the lower Fraser Valley. Two other isolated populations to the east occur on Pike and Missezula mountains.

Habitat

Mountain Beavers occupy underground den sites usually associated with deep friable soils near streams or seepages. Each adult occupies its own den site, with core use areas usually <1 ha, with the majority of activity within 25 m of the den. Forays of up to 200 m may occur. Their preferred habitat is open areas within forest and early-seral forest stages. These sites contain the highest abundance of preferred foods, including herbaceous plants, ferns, and young shrubs and trees.

Biology

Mountain Beavers live an estimated 5-6 years. Adult females (≥ 2 years old) have an average of 2.5 young in spring, with young dispersing from their natal dens in late summer. Dispersal abilities appear to be limited because the Fraser River has prevented geographic expansion of the species northward into what is apparently suitable habitat in the Coast Mountains, and the dry interior plateaus and valleys have prevented expansion into apparently suitable habitat in the wet belt of the Columbia Mountains. Mountain Beavers are limited to cool, wet sites because they lack the ability to effectively conserve water and they begin to experience hyperthermia when temperatures exceed 28°C.

Population Sizes and Trends

A minimum of 1500 Mountain Beaver dens, or occupied sites where at least 1 den is assumed to occur, are known in B.C. The total population size is unknown but is estimated to be >10,000 mature animals, as extrapolated from densities in known occupied areas and total amount of potential habitat in the range. Population size declined by unknown levels when approx. 700 km^2 of valley bottom in the lower Fraser Valley was converted to agriculture and urban/suburban development in the last 60 years and the range has contracted in the last 50 years on the west and eastern edges.

Threats and Limiting Factors

Climate change is considered a threat because Mountain Beavers require cool humid microclimates, and low ambient temperatures. Increasing summer temperature is expected to reduce distribution at the east side of their range in British Columbia. As well, the population on the western range likely would not be able to expand northward because the Fraser and Thompson rivers act as barrier to movement. The threat has not been quantified because the extent of mortality and range loss is not known.

In the lower Fraser River valley, habitat loss to urbanization continues with 100 km^2 zoned for new suburban development in two subpopulations of Sumas and Chilliwack mountains of the Abbotsford and Chilliwack areas. Development is ongoing in this area, but full conversion is not expected within the present 20-year planning horizon. Declines due to habitat conversion within the next 12 years are estimated to be less than 1% of total population because these sites represent a small part of the Canadian range.

Forestry has positive and negative impacts; food is created in clearcuts but machinery compacts soil used for denning. Silvicultural practices using heavy machinery can severely disturb the soil layer and are a major limiting factor preventing Mountain Beavers from using otherwise suitable habitat. Effective measures (i.e., harvesting only during deep snow periods) exist but their rate of application is unknown. In summary, clearcutting without soil compaction is beneficial for Mountain Beaver, but the extent of soil compaction is unknown. Therefore, as a very coarse estimate, the decline within the next 12 years is presented as a maximum, and is estimated as 3% if effective measures are not applied.

Protection, Status, and Ranks

Globally, Mountain Beavers are ranked by the IUCN as Least Concern with a stable population trend. In Canada, they are listed as Special Concern on Schedule 1 of SARA. They are ranked as vulnerable (S4) in B.C. Within B.C. a permit must be obtained to possess or kill them, but this does not apply to incidental mortality from unrelated activities (e.g., land clearing or timber harvesting). Measures undertaken to protect Mountain Beaver habitat within harvested sections of provincial forests during timber harvesting or silvicultural activities are voluntary. Approximately 79% of the range is in provincial forests, 18% in protected areas (including parks, recreation areas and ecological reserves), 2.8% in private lands and minor amounts in Department of National Defence Lands (0.2%) and First Nations reserves (0.1%).

TECHNICAL SUMMARY

Aplodontia rufa
Mountain Beaver — Castor de montagne
Range of occurrence in Canada: British Columbia

Demographic Information

Generation time Based on median of maximum breeding range of 2-6 years.	4 yrs
Is there an inferred, continuing decline in number of mature individuals?	Yes
Estimated percent of continuing decline in total number of mature individuals within 2 generations (8 years). *Very coarse estimate based on 2% maximum loss from forestry and 1% from development.*	Unknown
Suspected percent reduction in total number of mature individuals over the last 3 generations (12 years). *Very coarse estimate based on 3% maximum loss from forestry and 1% from development.*	Unknown
Suspected percent reduction in total number of mature individuals over the next 3 generations (12 years). *Very coarse estimate based on 3% maximum loss from forestry and 1% from development.*	Unknown
Suspected percent reduction in total number of mature individuals over any 10 year period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased? *Suburban development is continuing. Mitigation of forest impacts exists but the extent of application is unknown, and not assessed on the east side of the Cascade Mountains. Climate change is likely a factor in eastern range.*	Understood, but not ceased.
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence	12,120 km²
Index of area of occupancy (IAO)	3,496 km²
Is the total population severely fragmented? *Four populations are isolated but most of Canadian population exists within a contiguous block.*	No
Number of locations* *Housing development impacts each property differently in the western populations and separate forestry plans impact the other populations.*	> 10
Is there a projected continuing decline in extent of occurrence? *Range contraction has occurred and is predicted to continue with loss of 4 populations*	Yes
Is there a projected continuing decline in index of area of occupancy? *Range contraction has occurred and is predicted to continue with loss of 4 populations*	Yes

* See Definitions and Abbreviations on COSEWIC website and IUCN 2010 for more information on this term.

Is there a projected continuing decline in number of populations? *Range contraction has occurred and is predicted to continue with loss of 4 populations*	Likely
Is there a projected continuing decline in number of locations*? *Range contraction has occurred and is predicted to continue with loss of 4 populations*	Yes
Is there a projected continuing decline in extent of habitat? *Climate change likely to impact eastern populations*	Yes
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations*?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population	N Mature Individuals
Total Population Estimate based on density estimates and IAO	Unknown; likely >10,000

Quantitative Analysis

Probability of extinction in the wild is:	Not Conducted

Threats (actual or imminent, to populations or habitats)

Urban/suburban development, agricultural conversion, forestry activities using heavy machinery compacts soil and reduces habitat suitability.
Climate change could reduce their extent of occurrence in Canada, particularly at the east edge of their range where they are already limited in distribution by aridity and high summer temperatures. The Fraser and Thompson rivers prohibit possible northward geographic range expansion as a response to changing climates in the Cascade and Coast mountain ranges

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? Secure	
Is immigration known or possible?	Yes
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely? *Rescue of the four isolated populations is unlikely but immigration to main population is possible along the border where suitable habitat still exists. Rescue is considered to be limited because species has poor dispersal abilities.*	Limited

* See Definitions and Abbreviations on COSEWIC website and IUCN 2010 for more information on this term.

Current Status

COSEWIC: Special Concern (May 2012)

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Special Concern	Not applicable
Reasons for designation: The range of this species in Canada has contracted by 29% in the last 50 years and expansion into new habitat is constrained by large rivers. Within its range, habitat loss from urban development continues, and soil compaction caused by heavy machinery limits the use of otherwise suitable habitat. Climate change may further affect this species because it requires humid microclimates and low ambient temperatures. Rescue effect potential is limited by the short dispersal rate of the species and areas of unsuitable habitat along the border with the United States.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not Applicable. Decline in all ages of the species is estimated to be 4%.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not Applicable. EO of 12,120km^2 meets threatened (B1) and there is a continuing decline in elements of B1b. However, criterion is not met because number of locations exceeds 10 (B1a) and extreme fluctuations have not been recorded (B1c).
Criterion C (Small and Declining Number of Mature Individuals): Not Applicable. Population size is not known but density estimates suggest po lation exceeds 10,000 mature individuals.
Criterion D (Very Small or Restricted Total Population): Not Applicable. Population exceeds 10,000 mature individuals, exists in more than 5 locations and IAO is 3,496 km^2.
Criterion E (Quantitative Analysis): Not Applicable. PVA was conducted on general, published survivorship results across the species' range and not on actual population parameters for specific locations where viability may be an issue.

PREFACE

The first COSEWIC treatment of Mountain Beaver was based on Orchard (1984). It was assessed as Not at Risk, but was limited by a general lack of available data on the species. Under IUCN criteria established since 1994, this assessment would probably have been Data Deficient. COSEWIC reassessed the Mountain Beaver as Special Concern in 1999 (Gyug 1999). Using its new quantitative assessment criteria, COSEWIC confirmed that status in 2001, based on the existing 1999 report (COSEWIC 2001). The current report, drafted in 2010, is an update of the 1999 COSEWIC status report for the Mountain Beaver. This status report was in development prior to the formation of guidelines for inclusion of Aboriginal Traditional Knowledge (ATK); information regarding ATK used in the report is available in public documents but those documents have not been evaluated by the ATK Subcommittee of COSEWIC.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2012)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

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The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

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Mountain Beaver

Aplodontia rufa

in Canada

2012

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Scientific name: *Aplodontia rufa* (Rafinesque, 1817)

English name: Mountain Beaver

French name: Castor de montagne

Classification: Class Mammalia, Order Rodentia, Suborder Sciuromorpha, Family Aplodontiidae (Wilson and Reeder 2005)

The Mountain Beaver, the only member of the family Aplodontiidae, possesses some of the most primitive anatomical and morphological characteristics of any living rodent worldwide (McGrew 1941; Banfield 1974; Hall 1981). There are currently two recognized subspecies in Canada (Banfield 1974; Hall 1981): *A. r. rufa* (Rafinesque, 1817), located south of the Fraser River, and *A. r. rainieri* (Merriam, 1899), located east of the Fraser River. However, recent DNA analyses across the species' range (n=383 samples, 16 from B.C.) indicate that Mountain Beaver in Washington and B.C. are one subspecies (Ransome unpub. data; Piaggio pers. comm. 2010), and that there is no genetic basis for retaining the subspecies *A. r. rainieri*. Therefore, all samples from B.C. represent *A. r. rufa*. (Note: the current subspecies classification (*A. r. rufa*) may revert to *A. r. olympica,* reflecting a prior classification suggested by Merriam (1899) (Piaggio pers. comm. 2010).

The name Mountain Beaver was given by Sierra Nevada gold miners in the 1850s because it gnaws cambium from cut branches. 'Sewellel' was the first name applied in the literature by Lewis and Clark to Mountain Beavers, although that name actually referred to the coat made from Mountain Beaver fur (Coues 1893). Suckley and Gibbs (1860) reported the Yakima Indian name for Mountain Beaver as "Squallah", the Nisqually Indian name as "Show'tl", and the Chinook name as "0-gwool-lal". Mountain Boomer is another colloquial name applied because it "makes a kind of booming noise" (Coues 1877 quoting Dr. F.S. Matteson of Coquille, Oregon), although this noise has not been reported by other sources.

Morphological Description

The Mountain Beaver is a medium-sized rodent with the general appearance of a muskrat except the tail is well-furred and short. The body is thick, and covered with coarse, dark brown fur (Carraway and Verts 1993). Average adult body mass is 806 g (Lovejoy and Black 1974). In Canada, average mass of Mountain Beaver in the lower Fraser Valley is 948 g (Ransome unpub. data). Total length ranges from 300-470 mm, including the 20-40 mm long tail (Ingles 1965).

Population Spatial Structure and Variability

Mountain Beavers typically occur near streams or smaller drainages (i.e., seepage sites) because of their physical requirements for a cool thermal regime, abundant moisture, and adequate soil drainage (Beier 1989). These habitats tend to be localized and, on the east side of the Cascade Mountains in B.C., occur over continuous areas that are almost always <2.5 ha in size (Gyug 2000). Areas with high densities of Mountain Beavers are loosely referred to as colonies, but are recognized as being aggregations of solitary individuals (or an adult female with kits). These aggregations occur in high-quality habitat with inter-den spacing of at least 20 m maintained by territorial interactions (Martin 1971). Adults live alone in underground dens and are aggressive toward each other (Nolte *et al.* 1993).

Genetic variation is fairly high within B.C. with nine unique haplotypes found in 16 mtDNA samples (Ritland and Miscampbell pers. comm. 2010), suggesting limited movement between populations. Gene flow studies have not been done but sites are assumed to be genetically isolated when they are separated by several km of unsuitable habitat, or by a large river.

Designatable Units

In Canada, Mountain Beavers are found only in the extreme southwest portion of British Columbia. Two subspecies were previously thought to occur but recent genetic analyses (see **Name and Classification** section) indicate that there is only one subspecies in B.C. COSEWIC (2001) had previously recognized just one designatable unit for Mountain Beaver but did so because the subspecific boundary in B.C. had never been well defined (Cowan and Guiguet 1965), and there were no reliable morphometric characteristics upon which to assign specimens to either subspecies (Cosco 1980). There is a single designatable unit in Canada.

Special Significance

The Mountain Beaver is often referred to as a 'living fossil'. It is the only living species in the family Aplodontiidae, a group which split from sciurid-like rodents in the Eocene approx. 40 million years ago (McGrew 1941). It was unique enough that it was considered to be in its own suborder (Protogomorpha) (McGrew 1941) but genetic analyses have shown it to be part of the sciurid-like rodents (Sciuromorpha) (see review by Carleton and Musser 2005). Aspects of its anatomy are considered primitive, or like those of ancestral rodents (Carraway and Verts 1993). Conservation of water is a significant problem because Mountain Beavers, unlike other mammals, have a relatively undeveloped renal anatomy and limited ability to concentrate urine (Nungesser and Pfeiffer 1965).

Four species of flea are strongly associated with Mountain Beaver, and one species, *Hystrichopsylla schefferi*, the largest extant flea in the world, is host-specific to Mountain Beavers (Lewis 1994; Lewis and Lewis 1994).

Mountain Beavers are not currently valued for their fur or meat. Coastal First Nation peoples made Mountain Beaver skins into blanket-like robes (Coues 1893). The fur was not considered suitable or profitable for the fur trade (Suckley 1860; Godin 1964). Suckley and Gibbs (1860) reported that the Nisqually of the Puget Sound area considered "the show'tl was the first animal created with life" [p. 125] and placed high value on Mountain Beaver meat.

In the U.S. Pacific Northwest, Mountain Beavers often are considered a forest pest (Nolte and Dyzkeul 2002). The most common form of damage is clipping the tops of small seedlings for up to 4 years after planting (Borrecco *et al.* 1979), although conifers up to 2.5-cm diameter may be clipped (Nolte and Dyzkeul 2002). Up to 25% of newly planted Douglas-fir (*Pseudostuga menziesii*) seedlings can be lost to Mountain Beavers (Hooven 1977; Motobu 1978), and in localized areas with high densities of Mountain Beavers, it is difficult to regenerate planted conifers (Nolte and Dyzkeul 2002). Instances of damage have been reported in a few plantations in the Chilliwack Valley (Cosco 1980; Ransome unpub. data) but Mountain Beaver are not considered significant pests over most of their Canadian range.

DISTRIBUTION

Global Range

The family Aplodontiidae arose in western North America (Shotwell 1958). Currently, Mountain Beavers only occur within or west of the Cascade and Sierra Nevada mountain ranges of western North America (Figure 1; Hall 1981). They occur in northern California, in a small portion of Nevada near Lake Tahoe, the western parts of Oregon and Washington, and in extreme southwestern B.C. The Canadian range represents approximately 5% of the global distribution.

Figure 1. Global range of the Mountain Beaver, *Aplodontia rufa*, shown in dark grey (after Hall 1981).

Canadian Range

In Canada, Mountain Beavers are found in southwestern B.C. (Figure 2; Gyug 2000; Nagorsen 2005). The historical (i.e., < 1960) extent of occurrence (EO) of Mountain Beaver in Canada was 17,149 km^2 (Figure 2), using the minimum convex polygon method (IUCN Petitions and Standards Subcommittee 2010). The current EO is 12,120 km^2.

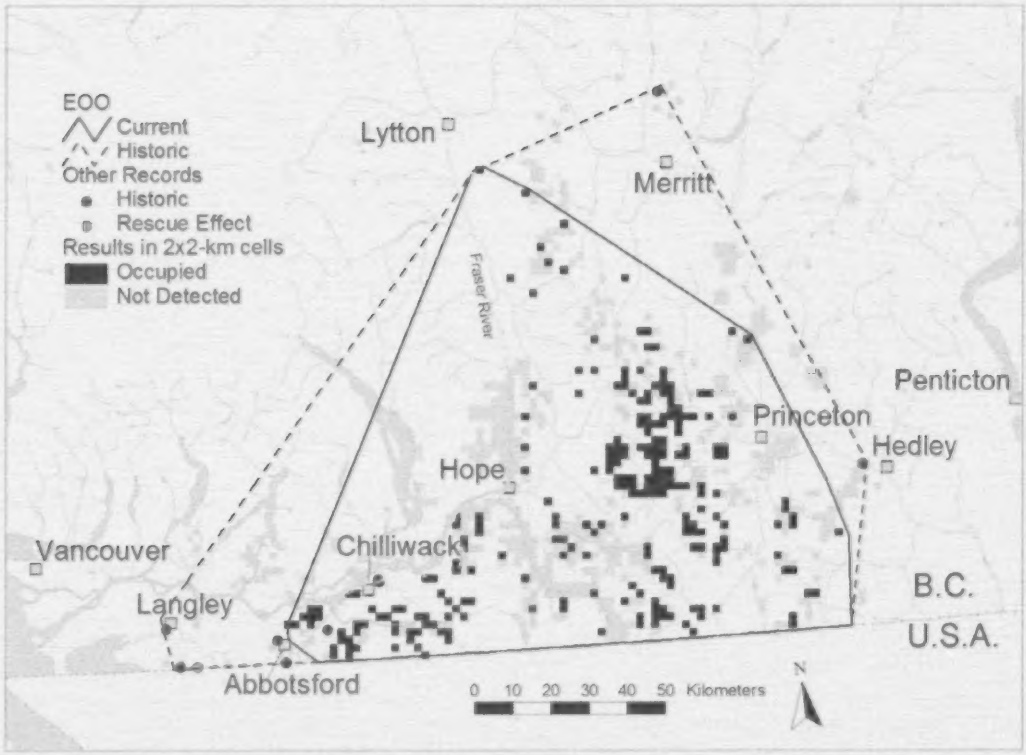

Figure 2. Extent of occurrence (EO) and areas searched for Mountain Beavers, *Aplodontia rufa*, in Canada showing all search results from 1996-2010 summarized on a 2×2-km cell basis, and including all historical records from Gyug (2000). The dashed line indicates the EO before the 1960s and the solid line indicates the current EO.

The species has most likely been extirpated prior to 2000 from two sites north of Merritt and near Hedley where it was documented in 1947 and 1928, respectively (Figure 2). Specific searches for Mountain Beavers in 2000, 2001 and 2003 recorded no evidence of Mountain Beaver dens, or animals in these and neighbouring areas (Gyug unpub. data). The dens are readily detectable and it is therefore unlikely that animals would not be detected where they had been previously. Mountain Beaver sign had been reported at a site north of Merritt (Gyug 2000) but is considered to be created by Red Squirrel (*Tamiasciurus hudsonicus*) caching behaviour (Gyug, unpub. data). Elsewhere, four sites in a previously unsearched area extend the range north of Princeton (Gyug unpub. data). Extensive surveys on the west side of the range since 1999 did not record Mountain Beavers north or west of the Fraser River (Ransome 2003; Keystone Wildlife Research, unpub. data).

Mountain Beavers use specific habitat within a particular area, and both the EO and area of occupancy (AO) overestimate the distribution of Mountain Beavers. The AO is estimated to be 7836 km^2 (Figure 3) and is based on the amount of land in 2x2-km blocks within the EO that is wetter than the 150-175 mm isoline of May-August average total precipitation (based on 1961-1990 monthly mean values; Centre for Forest Gene Conservation, 2010). Mountain Beavers are only found on the wetter side of the isoline. The northwestern boundary of occupied habitat aligns with the Fraser River. The AO also is based on the removal of 700 km^2 in the lower Fraser Valley where habitat had been converted to agricultural and developed land since European settlement (i.e., >50 years ago).

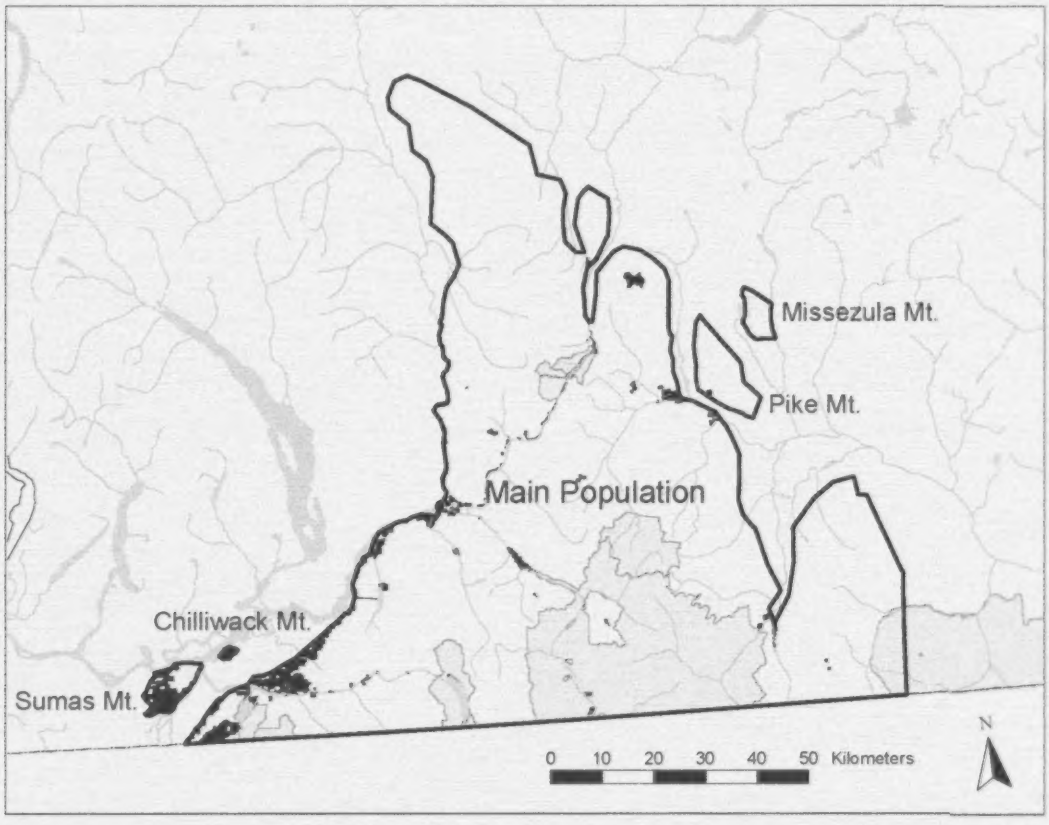

Figure 3. Mountain Beaver, *Aplodontia rufa*, populations in Canada showing the main population and four isolated populations. Private land holdings are shown in black; provincial parks are shown in green. The solid line indicates area of occupancy.

The index of area of occupancy (IAO) is estimated to be 3,496 km^2. A total of 558 2×2-km cells within the AO were surveyed and Mountain Beavers were detected in 249 (44.6%) of these cells (Figure 2). Assuming that the same detection rate would apply if all possible cells had been searched, the index of area of occupancy (IAO) would be 3496 km^2 (44.6% of the total area of 7836 km^2). Caution in interpretation is noted because the cells were searched during a variety of separate projects, and as such were not chosen randomly or searched equally. This is still the only estimate currently available.

The Canadian range exists as five populations (Figure 3). The main population is relatively contiguous and likely contains significant demographic and genetic flow. An additional four populations are recognized because they are isolated from one another by 2-6 km of unsuitable habitat, and gene flow between these units and the main population is likely very low. Two populations are at the west edge of their range on Chilliwack (AO; 4 km^2) and Sumas (AO; 64 km^2) mountains in the lower Fraser Valley. The other populations are on Pike (AO; 128 km^2) and Missezula (AO; 44 km^2) mountains on the eastern side of the Cascade Mountains.

Extensive surveys have confirmed that the range of the Mountain Beaver in the lower Fraser Valley has contracted (Figure 2; Ransome 2003). Mountain Beavers were recorded in the 1960s in several municipal parks west of Abbotsford (Ryder pers. comm. 2003), and Mountain Beavers had been recorded at two sites south of Langley in the past 30 years close to the U.S. border (Ransome 2003). No evidence of Mountain Beavers was noted in surveys of the municipal parks in 2003. A single animal found west of Abbotsford was probably a dispersing juvenile from Washington and not a member of a B.C. population (Ransome 2003). This individual was captured in a residential pond connected to Washington, U.S., by a culvert. There was no sign of local activity and immediately upon release it travelled south to Washington. In summary, the western extent of the population is now on Sumas Mountain northeast of Abbotsford, and Vedder Mountain southeast of Abbotsford (Figure 3).

The Canadian population of the Mountain Beaver in Canada consists of numerous locations, as defined by the COSEWIC definition of location being a geographically distinct area in which a threatening event can rapidly affect all individuals present. The main population and the two eastern populations (Figure 3) are subject to numerous forest harvest plans that vary in their likely impact on Mountain Beavers. The two western populations (Chilliwack and Sumas mountains) are threatened by housing development, and although subject to a single zoning exercise, there is enough variation in impact on Mountain Beavers from each development, that each property is considered a location.

Search Effort

Extensive surveying and data gathering from 1996-2010 have greatly increased our knowledge of the distribution and abundance of the Mountain Beaver. Surveys done since those reported in Gyug (2000) include Ransome's (2003) survey of 283 sites, mostly in the lower Fraser Valley. Between 20 min. and 3 hours of search time was allocated per site depending on its size (< 1 ha to 60 ha). Mountain Beavers were found at 94 sites. In 2000 and 2001, Keystone Wildlife Research (unpub. data) surveyed 358 habitat plots west of the Fraser River, and 1324 south or east of the Fraser River near Hope. No Mountain Beaver sign was found west of the Fraser, but sign was found on 26 plots south or east of the Fraser River. These small plots (400 m^2) were part of an ecosystem mapping project and not selected specifically as potential Mountain Beaver habitat. In 2000-01, Gyug (unpub. data) recorded Mountain Beaver sign in 26 of 360 sites on the east side of the Cascades while surveying for other species. Gyug (unpub. data) searched about 45 km of a proposed pipeline corridor on the east side of the Cascade Mountains in 2002 and found Mountain Beaver sign at nine sites. A site is defined as a contiguous area with Mountain Beaver sign up to 500 m in length, usually along streams. Gyug (2005) conducted a survey of Skagit and E.C. Manning Provincial Parks with Mountain Beaver sign found at 11 of 21 sites totalling about 1000 ha (range 4 to 200 ha). This sign included 110 occupied dens, eight sites with fresh diggings or clippings (Figure 4), and 20 old sets of tunnels without fresh sign. Other incidental sightings of Mountain Beavers, or their sign, were provided by Ransome (unpublished data, n = 40), Gyug (unpublished data, n = 12), Department of National Defence (n = 17; Bears and Hammond 2010; Knopp and Larkin 2004), and by various naturalists to Gyug (n = 18).

In summary, the general distribution of Mountain Beaver is well known. Population size is not well known because search effort has not been intensive within the range; <50% of all 2x2-km cells of potential habitat have been surveyed.

HABITAT

Habitat Requirements

Mountain Beavers need soils that allow tunnel, runway, and burrow construction, a cool and moist microclimate within tunnels and burrows, and suitable food within 50 m of the den (Martin 1971; Carraway and Verts 1993). Subsurface drainage that keeps most tunnels and burrows wet, even to the point of having water trickling through them, appears ideal (Beier 1989; Carraway and Verts 1993; Gyug 2000). While runways and tunnels may be quite wet, underground den sites must still be dry and above the water table. Deep soils appear to be a prerequisite to establish dens and tunnel systems (Camp 1918).

Mountain Beavers occur in forests of any age but appear to prefer early to mid-seral stages where herbaceous food is abundant (Neal and Borrecco 1981; Carraway and Verts 1993). An important feature is the presence of permanent openings associated with streams and seepage zones (Gyug 2000). In forested portions of the lower Fraser Valley, Mountain Beavers commonly occur at sites ranging in age from recent clearcuts to 15-year-old sites with either moist seepage sites or areas dominated by lush vegetation (Ransome unpub. data). Coastal populations may attain peak densities in areas of early- to mid-seral stages vegetated by young (i.e., 20 year old) second-growth trees, shrubs, and forbs (Scheffer 1929; Dice 1932; Svihla and Svihla 1933; Hooven 1973, 1977).

In the eastern Cascades, the highest densities of Mountain Beaver were in seepage areas of upper-elevation coniferous forests dominated by Engelmann Spruce (*Picea engelmannii*), Subalpine Fir (*Abies lasiocarpa*) and Amabilis Fir (*A. amabilis*) (Gyug 2000). These sites were fine-grained mosaics of sub-hygric to hygric forest interspersed with small meadows where the water table was either at, or close to, the surface. Most foraging appeared to take place in wetter meadows, which were criss-crossed with runways; dens were usually found under tree root masses within adjacent forests.

Dens were located immediately adjacent to seepage areas on lower slopes or alluvial fans where parent materials originated from moraines, but not in valleys of large streams or rivers with well-developed gravel or cobble floodplains dominated by coarse glacio-fluvial parent materials (e.g., the Skagit Valley of B.C.) (Gyug 2000, 2005). Mountain Beavers tend to occur on smaller streams at higher elevations rather than in more flood-prone, higher-order, lower-elevation streams (Gyug 2000; Beier 1989). Dens have been found at elevations from sea level to 1925 m (Gyug 2000; Ransome unpub. data), and on slopes up to 73% (Gyug 2000). On the east side of the Cascades, on smaller streams or in seepage areas >50 m from a mapped stream, more dens were found on steep aspects (286°-135°) (Gyug 2000).

Habitat Trends

Changes in habitat relate to three threats; climate change, habitat loss from development, and forestry (see **Threats** section).

About 700 km^2 of Mountain Beaver former range in the lower Fraser Valley has been converted to agricultural and urban/suburban development since European settlement (Gyug 2000). No significant additional land is being lost to agricultural conversion because most arable land is already in use. However, urban/suburban development is continuing in the lower Fraser Valley, with approx. 100 km^2 of Mountain Beaver habitat zoned for future development in the City of Abbotsford (2005), City of Chilliwack (1996, 2007) and in Electoral Area "G" in the Fraser Valley Regional District (2008). Development of some of this area is currently under way, but the entire area is not expected to be developed within the present 20-year planning period, except on Chilliwack Mt., which is <5 km^2 in size, and where development began in the 1990s. It is

not possible to accurately estimate amount of habitat that may be lost in the next 12 years (3 generations) because the amount and precise location of Mountain Beaver habitat on Chilliwack and Sumas mountains is unknown. It is possible that the Chilliwack and Sumas mountain locations will be extirpated in the future, but not within 3 generations.

Most of the range of Mountain Beaver is subject to forest management. The effect of forestry is difficult to quantify because forestry can have negative and positive benefits on Mountain Beavers. Significant canopy removal (i.e., from clearcut and other harvest practices) may lead to increased habitat suitability because of an increased production in food. However, harvesting may also lead to a decrease in habitat suitability because of soil disturbance and compaction by heavy machinery (Gyug 2000). In a post-hoc study on the east side of the Cascades, where various forms of clearcutting had occurred over a period of 8 years prior to the study year (1997), Mountain Beaver densities on sites harvested with heavy machinery (n= 458 stands) were 85-95% lower than on sites (n= 459) harvested without severe machine disturbance (Gyug 2000). Longer-term studies are unavailable. Soil compaction results from heavy machinery harvesting and hauling trees and scarifying the site for planting (Gyug 2001). Ditching of streams and piling of coarse woody debris into streams also impacted Mountain Beaver habitat (Gyug 2000). Broadcast burning after clearcutting has been found to cause direct mortality of up to 50% of a Mountain Beaver population (Motobu 1978), but broadcast burning in B.C. did not appear to affect long-term suitability as long as soils were not excessively compacted (Gyug 2000; Gyug unpub. data).

Habitat losses are more difficult to address for Mountain Beaver located on the west side of the Cascades. Factors influencing Mountain Beaver densities are less known, partly because densities are more difficult to determine (Ransome, unpub data), but also because research was done in the U.S. and concentrated on trying to keep Mountain Beavers out of regenerating clearcuts as a means of preventing damage to young conifers (e.g., Arjo *et al.* 2004, Arjo *et al.* 2009). In a study west of the Cascades in coastal Washington State, Mountain Beavers recolonized clearcuts, regardless of eradication measures, or which type of timber harvesting was undertaken (Arjo 2010).

A before-and-after study was initiated in 1998 to determine if harvesting effects could be mitigated. Sites were clearcut but only during periods of deep snowpack (which shouldn't compact soil), and heavy machinery was not allowed on tunnel networks (Gyug 2001). In 2010, Gyug (unpub. data) enumerated all dens within 13 cutblocks (mean size 24 ha, range 3 - 41 ha), which were then between 2 and 12 years after clearcutting. Density after harvest (0.58 (± 0.17)) was similar to pre-harvest density (0.61 dens/ha (± 0.22 SE)) suggesting that Mountain Beaver numbers will not necessarily decline in clearcuts when attempts are made to limit soil compaction and disturbance in occupied microsites. However, such practices are voluntary and data do not exist on their application in Mountain Beaver range.

Some impacts of forestry have been partially mitigated since the last COSEWIC assessment in 2001. The B.C. Forest Practices Code and other policies resulted in a 79 ha Wildlife Habitat Area designated for Mountain Beavers in the Chilliwack area, and buffer strips of different widths on mapped waterways. Heavy machinery is not allowed within a 5 m buffer closest to the stream. The regulation prohibits ditching of streams and piling of debris in waterways. The *Forest and Range Practices Act* (2004) replaced these prescriptive-based practices with results-based practices that are more associated with increased self-monitoring by industry. Data on compliance are not available.

The 5-m wide buffer strips are of value to Mountain Beavers because soil will not be compacted. However, habitat use extends beyond the 5 m; distance to stream was recorded for 253 active dens in 1997-1998 and only 19% were within 5 m of the waterway (L. Gyug, unpub. data). As well, seepage zones created by sheet drainage are used by Mountain Beavers but these sites are not buffered. Approximately 80% of Mountain Beaver den sites in habitat managed for forestry would not necessarily be protected from heavy machinery (L. Gyug pers. comm.).

In summary, some forest practices detrimental to Mountain Beavers are no longer conducted, but other practices (i.e., soil compaction) likely are an issue over large areas because the extent of voluntary practice that would minimize soil compaction is not known. Buffer strips provide protection to approx. 20% of habitat subject to forestry.

BIOLOGY

Most data on Mountain Beaver biology derive from studies conducted in the northwestern U.S., but these data are assumed to be representative of Mountain Beavers within B.C.

Life Cycle and Reproduction

Mountain Beavers have one litter per year between February and May, depending on elevation (Carraway and Verts 1993; Feldhamer and Rochelle 2003). Litters usually comprise 2-3 young, occasionally 4, and mean litter size is 2.5 young per female (Carraway and Verts 1993). Gestation lasts 28-30 days and the young are weaned at two months (Carraway and Verts 1993; Feldhamer and Rochelle 2003). The young leave the natal den sometime in summer or fall of their year of birth.

Adult females do not breed until two years of age (Carraway and Verts 1993). Estimated longevity is 5-6 years, based on live-trapping studies (Martin 1971; Lovejoy and Black 1979a). The generation time is estimated as 4 years, based on the median of the maximum breeding range of 2- 6 years. Annual adult survivorship has been estimated at 64% (Lovejoy and Black 1979a), approx. 50% (range 0.19-1.00; Arjo *et al.* 2007), and 65% (range 0.56-0.82; Arjo 2010). These survival estimates appear unsustainable but the results of a single sex, 2-stage pre-breeding matrix model, with a

female survival rate of 60% (for yearling, juveniles and adults), a longevity of 5 years, and a fertility rate of 1.25 female yearling per adult per female suggest that a stable population would occur (P. Nantel pers. comm. 2011). A population viability analysis (Vortex 9.9) on published survivorship data similarly concluded that the recorded survivorship rates could be sustained (G. Sutherland pers. comm. 2011).

Physiology and Adaptability

Mountain Beavers have an inefficient renal system that cannot produce hypertonic urine; therefore, they must consume large amounts of water, either directly or in their food (Nungesser and Pfeiffer 1965). This physiology limits them to living in areas with a cool and humid microclimate (Carraway and Verts 1993). They have poor thermoregulatory capabilities and are unable to sustain activity at ambient temperatures >28°C (Johnson 1971). Lethal body temperatures are reached after two-hour exposures to ambient temperatures between 32-35°C (Johnson 1971). Mountain Beavers are hindgut fermenters and practice coprophagy, producing both soft and hard fecal pellets, and re-ingesting the soft pellets (Ingles 1961). Information on winter activity is limited, but Mountain Beavers are active throughout winter and forage for plants and bark in tunnels under the snow (Ransome 2003).

Diet

Mountain Beaver eat a range of herbaceous and shrub plant species. The shoots and cambium of shrubs and trees may be eaten in any season (Verts and Carraway 1998). A wide variety of herbaceous plant material is stored as 'haypiles' in front of the burrow (Figure 5, Gyug 2000). This "hay" is left above ground until wilted, possibly in order to decrease how quickly it will rot once the material is moved into the burrow for storage and consumption (Voth 1968; Karban *et al.* 2007).

Home Ranges, Density and Dispersal

Mountain Beavers are non-migratory and generally use the same home ranges and den sites year round (although on rare occasions an adult will switch den sites; Martin 1971). Based on radio-telemetry, 90% of activity was within 25 m of dens, and 99% within 50 m (Martin 1971). In the Cascades, Gyug (2000) found most fresh activity and runways within 50 m of dens, but well-used runways sometimes extended up to 125 m from dens. Average home range sizes, derived from radio-telemetry and live trapping, are 0.10-0.32 ha (Martin 1971; Lovejoy and Black 1979b; Neal and Borrecco 1981). Recent radio-telemetry data in coastal Washington found much larger home ranges (95% kernel method) averaging 4.8 ha and 1.4 ha at two sites (Arjo *et al.* 2007), and 2.6 ha in forests, but 0.7-0.8 ha after timber harvest (Arjo 2010). Some long-distance forays of over 200 m from den sites were noted (Arjo *et al.* 2007).

Density of Mountain Beaver dens in quality habitat on the east side of the Cascades in Canada ranged from 0.24 to 1.1 dens/ha in census areas (Gyug 2000). In lower quality habitats, densities were 0.05-0.06/ha (Gyug 2000). Densities in Skagit and E.C. Manning Provincial Parks in B.C. ranged from 0.15-1.74 dens/ha (Gyug unpub. data). The highest densities found in B.C. to date ranged from 4.4-5.8 den sites/ha on the east side of the Cascades (Gyug 2000). Den densities reported from coastal Washington and Oregon were 0.5-4.4/ha (Arjo *et al.* 2007), 3.2-3.8/ha (Neal and Borrecco 1981) and 4.1-5.4/ha (Lovejoy and Black 1979a). The densities in high quality habitats on the east side of the Cascades in B.C. were similar to these. The only density estimate (0.67 individuals/ha) from the coastal side of the Cascades in B.C. is from one live-trapping study on Sumas Mountain (Salvador and Gravel 2010; Ransome unpub. data).

Mountain Beavers appear to have relatively poor dispersal capabilities. The species' post-glacial expansion appears to have been unable to expand their range northward across the Fraser River into apparently suitable habitat, nor were they able to expand into apparently suitable habitat in the interior wet belt of the Columbia Mountains (Gyug 2000). Martin (1971) found 9 of 10 young dispersing from their natal dens remained on his study site with the other establishing a den 570 m away. Arjo *et al.* (2007) found average dispersal distance of 148 m (n = 7; maximum 326 m) from natal dens but did so opportunistically because they did not radio-collar juvenile Mountain Beavers.

Interspecific Interactions

Arjo (2003) estimated annual Mountain Beaver loss to predators of 40%, with predation accounting for 70-75% of Mountain Beaver deaths at 2 study sites (Arjo *et al.* 2007). They are prey for a number of predators including hawks, owls, mustelids, Bobcats (*Felis rufus*) and Coyotes (*Canis latrans*) (Carraway and Verts 1993; Arjo *et al.* 2007). Mountain Beaver burrows and tunnels are frequently co-opted by Red or Douglas' squirrels (*Tamiasciurus douglasii*) for use as cone caches (Gyug unpub. data). Mountain Beavers have four species of fleas for which they are the specific host species (see **Special Significance** section).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Mountain Beaver census areas in B.C. have been sampled opportunistically, concentrating on likely habitats or areas where timber harvesting has been proposed (Gyug 2000, 2001, 2005, unpub. data). The presence of Mountain Beaver usually is derived from fresh sign at den entrances and each active den is assumed to contain one Mountain Beaver.

Survey activity in B.C. has focused on establishing presence (see Gyug 2000 and "Search Effort" above) rather than estimating density. The ability to estimate density is influenced by vegetative differences on either side of the Cascades. On the east side, den sites can be recognized in summer and autumn because of their regular spacing, and large haypiles at den entrances (Figure 4, 5) which permit estimates of individual density and abundance within defined areas (Gyug 2000; Gyug 2001; Gyug 2005). However, on the west side of the Cascade Mountains, it is difficult to determine number of occupied dens at any one site because Mountain Beavers inhabit densely vegetated shrub and fern sites that limit consistent detection of haypiles and fresh sign (Ransome 2003; Gyug 2005). Mountain Beaver densities on the west side of the Cascades should generally be determined by live-trapping studies (e.g., Salvador and Gravel 2010), which are relatively time- and labour-intensive. Only one live-trapping study has been attempted in B.C. (Salvador and Gravel 2010).

Figure 4. Fresh 'kickout' of soil from an active Mountain Beaver den, Manning Provincial Park, British Columbia, September 2005. (Photo by L. Gyug.)

Figure 5. Active dens typically contain 'haypiles' of cut vegetation at the entrance, Tulameen Valley, British Columbia. (Photo by L. Gyug.)

Abundance

The overall population size of Mountain Beavers in Canada is unknown but likely is >10,000 mature animals. The estimate is very coarse; census areas were not selected randomly, either range-wide, or within mapped strata of habitat suitability or capability. Approximately 1500 dens have been located but many more are expected within suitable habitat, especially on the western range where vegetation makes it difficult to detect dens. Density estimates in B.C. range from 0.05 to 5.8 dens/ha [= 5 to 580 animals/km^2, or 10 to 1160 animals/2x2-km cells] (see **Home Ranges, Density and Dispersal** section) and the estimated IAO is 3,496 km^2. Fewer than half of all 2x2-km cells of potential habitat used in the IAO estimate have been surveyed. Quantifying the actual area searched was not possible because the searches were the result of a variety of projects with many different aims, and the original data were not always available. Higher resolution mapping (i.e., 1:10,000 scale) of local soil moisture levels and soil compaction are needed to estimate total habitat and populations.

Fluctuations and Trends

Mountain Beaver populations appear to fluctuate locally with the abundance of early-seral stages of forest development containing appropriate soil and moisture conditions. Multi-year live-trapping studies conducted at the local scale of a few hectares have revealed annual population fluctuations on the order of 20% (Lovejoy and Black 1979a; 4.2 to 5.4/ha) and 50% (Arjo *et al.* 2007; 0.49 to 0.99/ha on one site, 2.13

to 4.38/ha on another site) of the maximum density found. Fluctuations in Mountain Beaver numbers over large areas likely are relatively minor because a small percentage of the range is harvested annually.

The range of the Mountain Beaver has contracted by approximately 29%, based on the change from historic EO to current EO in the last 50-60 years (Figure 2). Sites in the north and eastern range near Merritt and Hedley have been extirpated. The western sites near Langley are extirpated. These declines occurred beyond the 3-generation (12 years) period used by COSEWIC. More recent declines have been noted anecdotally in the lower Fraser Valley on agricultural lands, and on adjacent foothills (Gyug 2000; also see **Threats and Limiting Factors** section).

Rescue Effect

Mountain Beavers have limited long-range dispersal ability. However, short range dispersal may occur relatively quickly. Sites have been eradicated of Mountain Beavers but then re-occupied within 1 year, presumably from adjacent areas (Hacker and Coblentz 1993; Arjo *et al.* 2007). Local dispersal may assist Mountain Beavers in the main subpopulation because habitat is suitable in some areas adjacent to the U.S. border. Mountain Beavers west of Abbotsford, B.C. have been extirpated but could receive immigrants from Washington State, as evidenced from a single animal record (see **Canadian Range** section). The rescue effect would not apply to any of the four locations outside the main range, as dispersal to these sites is unlikely across several km of unsuitable habitat. In summary, rescue effect is possible but would be limited to the main subpopulation, and would occur slowly because of the lack of long-distance movement in the species.

THREATS AND LIMITING FACTORS

The range of the Mountain Beaver in Canada has contracted and the species appears vulnerable to three principal threats: climate change, urban development, and forestry.

Climate Change

Mountain Beavers are likely sensitive to climate change because of their requirement for abundant free water, cool humid microclimates, and low ambient temperatures (see **Physiology and Adaptability** section). Climate change projections for the specific range of the Mountain Beaver are limited, but one projection predicts that median summer temperatures will increase in the Lilloet-Squamish region by 1.7˚C, and precipitation decrease by 13%, by 2050 (Pacific Climate Impact Consortium). Individuals on the east side of the Cascades would be most affected as this is where their range is currently limited by aridity and high summer temperatures. Increasing summer temperature would probably result in a reduced distribution at the east side of their range in British Columbia because of the species' inability to tolerate heat.

Northward range expansion along the cool and wet Coast and Cascade mountain ranges is blocked by the Fraser and Thompson rivers (Figure 3). Increased temperature likely would cause movement to higher elevations and a reduction in total habitat area. At present, although climate change is a concern, the threat cannot be quantified because empirical studies on physiological response to projected climate change have not been conducted or modelled.

Urban and Agricultural Development

Mountain Beavers have been extirpated in the last 50 years from the valley bottom of the lower Fraser Valley (approx. 700 km^2 of their historical EO range) due to habitat loss through urbanization and agriculture (Gyug 2000) (see **Habitat Trends** section). The cities of Chilliwack and Abbotsford, and the Lower Fraser Regional District plan to develop foothill and hillside sites because the valley bottoms are either already developed, or in the Agricultural Land Reserve.

Mountain Beavers were previously abundant on some of the foothill sites already developed into suburbs (Knopp pers. comm. 1998, 2010). Ongoing urban or suburban development on isolated Sumas and Chilliwack mountains would most likely result in direct declines in these isolated sites (Letay pers. comm. 2010). Suburban development is also a risk to foothill sites at Vedder Mountain, Promontory and Ryder lakes areas within the City of Chilliwack where declines in Mountain Beavers have already been noted (Knopp pers. comm. 1998, 2010). In total, 2.8% of the Mountain Beaver range in Canada is within private land holdings (see **Habitat Protection and Ownership** section). Given that the areas to be affected may have some higher quality habitat than other areas of the range (Doug Ransome, unpub. data), even with complete development of these private land holdings, the extent of the threat is unlikely to extend to >5% of the total Canadian population on the long term. Over a 12-year period, the extent of this threat is unlikely to exceed 1% of the total population.

Approximately 50% of Sumas Mt. is in private ownership and has been incorporated into the City of Abbotsford of the Fraser Valley Regional District, and most lands are part of conceptual future community (development) areas (City of Abbotsford, Bylaw No. 584-2003). About 80% of Chilliwack Mt. is in private ownership and is within a Comprehensive Development Area (City of Chilliwack 1996, 2007, Official Community Plan 1998). No estimate is available for what percentage of habitat or of the subpopulations in the isolated locations of Sumas and Chilliwack mountains might be under threat in the next 12-year period, but over the next 20-year period, at least 50-80% of these locations are likely to be developed and the habitat rendered unsuitable.

Additional decreases in abundance may result from removals (lethal or relocation) by homeowners to protect plantings (Ransome, unpub. data), incidental mortalities from pets and vehicles, and possible increase in predators associated with urbanization (i.e., Coyotes). These threats are localized and not likely significant.

Timber Harvesting and Silvicultural Activities

The impact of forestry on the Mountain Beaver is discussed in the **Habitat Trends** section. Clearcutting and associated silvicultural practices (i.e., soil compaction) on the east side of the Cascade Mountains in B.C. were previously identified as the major threat affecting Mountain Beaver use of otherwise suitable habitat (Gyug 2000; also see **Habitat Trends** section), but not in the western part of their range, at least in Washington State. Intensive forest management practices have been increasing since the 1970s in B.C. as logging operations become highly mechanized. Eventually these mechanized practices will apply to the entire harvestable land base. This could be near 60% of the Mountain Beaver range because approx. 20% would be in riparian buffer strips (see **Habitat Trends** section) and 20% is protected in parks or ecological reserves, or is in private lands (see **Habitat Protection and Ownership** section).

The percentage decline in Mountain Beaver populations due to forestry is unknown, but is considered small. Mountain Beaver densities in heavily impacted sites were 80-95% less than those in sites clearcut using effective measures (Gyug 2000; see **Habitat Trends** section). As a rough estimate, given an approximate 100-year rotation for managed forests, approximately 1% of the timber harvest land base would be harvested per year, or approximately 12% in a 12-year (3 generation) period. Therefore, timber harvesting might be expected to negatively affect about 7% of the Mountain Beaver population in a 12-year period (60% of population impacted by forestry; 60% of 12% = 7%). Because some of the detrimental practices associated with declines in Mountain Beaver are no longer widely practised and some effective measures are applied, the estimate is reduced from 7% to 6%. Because forestry did not appear to impact populations on the west side of the species' range, the estimate is reduced by half, to 3%. The above estimate does not apply the Gyug (2001) results, which suggested no apparent impact to Mountain Beaver populations if effective measures are taken to avoid soil compaction. This result was not applied because the measures are voluntary, are believed to not be widespread, and not quantified.

Some areas in B.C. are established as Wildlife Habitat Areas for Coastal-tailed Frog (*Ascaphus truei*) and presumably these protected sites would result in limited soil compaction and benefit Mountain Beaver. However, their value is hard to quantify because Coastal tailed Frogs generally use different types of waterways than Mountain Beaver, and the proportion of Mountain Beaver habitat within the WHA would be small and variable (L. Gyug, unpub. data.). A more accurate estimate of protection from forestry would require data on proportion of habitat compacted by all silvicultural practices.

PROTECTION, STATUS, AND RANKS

Legal Protection and Status

Mountain Beavers have been listed as Special Concern under Schedule 1 of the *Species at Risk Act*. A draft management plan was prepared in 2005, but has yet to be finalized (Dyer pers. comm. 2010). All native terrestrial vertebrates are recognized as wildlife under the *Wildlife Act of B.C.* (B.C. Ministry of Environment 2010). A permit would be required in order to kill Mountain Beavers as they are not on Schedule "B" or Schedule "C' of the Designation and Exemption Regulation that allows certain nuisance or introduced species to be killed without permit.

No specific management of Mountain Beaver habitat is currently required of forest licensees in B.C. because Mountain Beavers are not designated as Identified Wildlife, nor are their den sites identified as Wildlife Features under regulations in the 2004 Forest Planning and Practices Regulation of the *Forest and Range Practices Act of B.C.* Mountain Beaver had been designated as Identified Wildlife and a single site was designated as a Wildlife Habitat Area in the Forest Practices Code (1995-2004).

Non-Legal Status and Ranks

Aplodontia rufa is ranked by the IUCN as Least Concern (Fellers *et al.* 2008). *A. rufa* is ranked by NatureServe as secure globally (G5; last reviewed 1996) and vulnerable within B.C. (S4) (B.C. Conservation Data Centre 2010).

In the U.S., Mountain Beaver is ranked nationally as secure (N5) with state rankings of secure (S5) in Washington, apparently secure (S4) in Oregon, critically imperiled (S1) in Nevada and vulnerable (S3) in California (NatureServe 2011). In Oregon, the state conservation organization does not list the Mountain Beaver (Oregon Biodiversity Information Centre 2010). Subspecies at the southern edge of their range include the Sierra Nevada Mountain Beaver (*A. r. californica*) ranked as vulnerable (T3T4), the Point Reyes Mountain Beaver (*A. r. phaea*) as imperiled (T2), and the Point Arena Mountain Beaver (*A. r. nigra*) as imperiled (T1) (NatureServe 2011); the latter has also been federally listed as Endangered (U.S. Fish and Wildlife Service 1991).

Habitat Protection and Ownership

The majority of Mountain Beaver range occurs on provincial Crown lands (96.9%), with minor amounts on private lands (2.8%), Department of National Defence Lands near Chilliwack (0.2%), and on First Nations Reserves near Chilliwack (0.1%). Approximately 18% (1412 km^2) of Mountain Beaver range is in 30 parks, recreation areas or ecological reserves that are protected from industrial resource extraction. A 79-ha Wildlife Habitat Area for Mountain Beavers currently exists in the Chilliwack area. Most (79%) of the protected area is in three protected areas that form a contiguous block: E.C. Manning Provincial Park, Skagit Valley Provincial Park, and Cascade Recreation Area. This block is adjacent to the U.S. border adjoining Ross Lake National

Recreation Area and Pasayten Wilderness in northern Washington. The remaining 20% of the 1412 km^2 is in six protected areas: Cathedral Provincial Park, Chilliwack Lake Park, Coquihalla Summit Recreation Area, Coquihalla Summit Provincial Park, Cultus Lake Provincial Park, and Liumchen Ecological Reserve. In the B.C. parks system, Recreation Areas and Class A provincial parks receive protection from resource extraction.

Protection of Mountain Beavers and Mountain Beaver habitat during timber harvesting or other silvicultural activities is voluntary. Voluntary guidelines have been developed for urban development in or adjacent to Mountain Beaver habitat on private lands in the lower Fraser Valley (B.C. Ministry of Environment 2006).

ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

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COLLECTIONS EXAMINED

No collections were examined in the preparation of this updated status report.